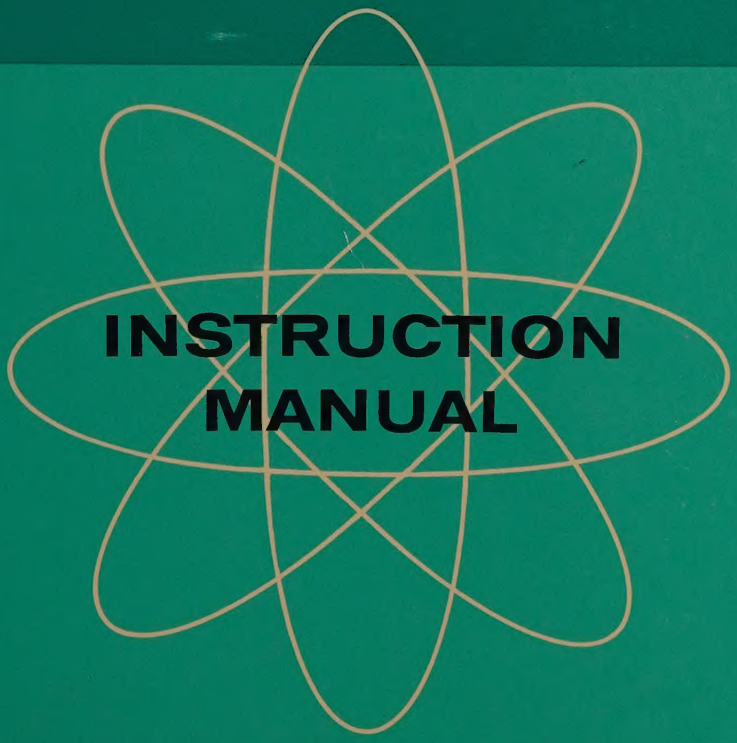
S-11

S-11

LING ELECTRONICS



INSTRUCTION MANUAL

MP MASTER
MA34256

Model
S-11
SERVO SYSTEM

IN ALL CORRESPONDENCE WITH THE FACTORY BE SURE TO INCLUDE THE FOLLOWING INFORMATION:

FROM SERIAL NO. _____

TO SERIAL NO. _____

LING NO. 41850

UNIT SERIAL NO. _____

LING ELECTRONICS Division
LING-TEMCO-VOUGHT, INC.
1515 So. Manchester Avenue
Anaheim, California

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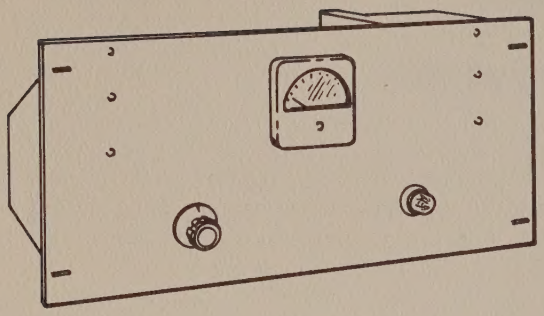
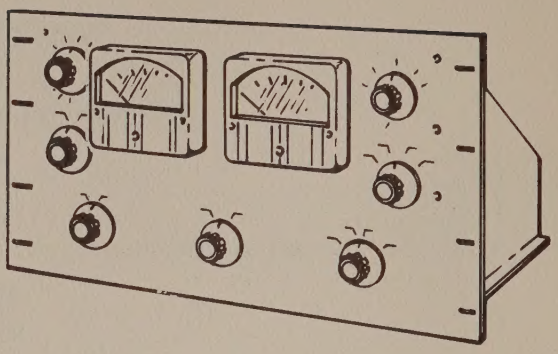
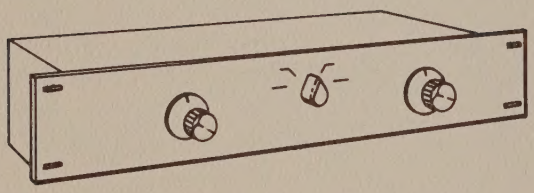


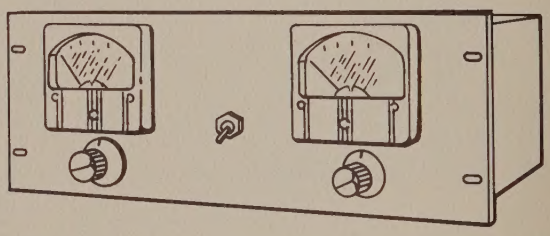
Model S-10 Servo Control Amplifier



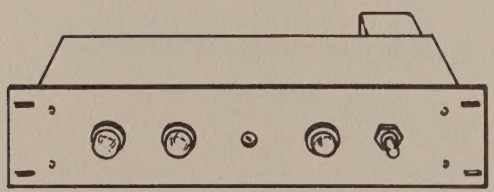
Model S-12 D&G Amplifier



Model SP 225 Switch Panel



Model 225 Signal Monitor



Model DA-10 Control Selector

Model S-11 Servo System

SECTION 1
DESCRIPTION AND CHARACTERISTICS

1-1. GENERAL

a. The Ling Electronics Model S-11 Servo System accurately regulates the vibration level at the shaker in a complete vibration testing system. Depending on configuration, the S-11 can control displacement, or acceleration as desired; it can operate with inputs from either accelerometers or velocity pickups mounted on the shaker or specimen. Various configurations of the S-11 are possible to provide multiple level control. For example: displacement control over one range of frequencies and acceleration control over another range of frequencies, or acceleration control along more than one axis. The S-11 Servo System may be used with any size shaker or power amplifier; it provides the following three characteristics:

(1). Accurate acceleration control from 0.5 to 100 g peak.

(2). Displacement control from 0.01 to 1.0 inches da.

(3). Velocity control over the range 0.1 to 100 inches per sec peak.

b. The S-11 Servo System consists of a number of basic "building blocks". These may be combined in various ways and in varying quantities to produce a servo system for the application required. The basic units are the S-12 D & G Amplifier, the 225 Signal Monitor, SP-225 Switch Panel, the DA-10B Control Selector and the S-10B Servo Control Amplifier. In an actual S-11 Servo System, a number of S-12 and/or 225/SP-225 units may be used combined with a number of DA-10B Control Selectors and one S-10B unit.

c. This manual is designed to apply to the usual configurations of the S-11 Servo System. The manual is organized so the basic units (S-12, 225/SP-225, S-10B and DA-10B) are treated separately with an instruction book for each unit. The main body of the test applies to the system aspects of the servo rather than the detailed blocks from which it is made.

1-2. PURPOSE

a. The purpose of the S-11 Servo System is to hold displacement or acceleration constant, at a shaker, as frequency or other parameters are varied in a vibration testing system.

1-3. CHARACTERISTICS AND SPECIFICATIONS

a. All units of the S-11 are designed for rack mounting and may be installed in either consoles or standard racks, depending on the application. The important specifications for the system are:

(1). Control Range:

(a). Acceleration . . . . . 0.5 - 100 g peak

(b). Displacement . . . . . 0.01 - 1.0 in da

(2). Input Transducer:

(a). S-11D-1 . . . . . Velocity pickup and/or accelerometers (acceleration only).

(b).	S-11D-2	Accelerometer and velocity pickup (displacement only).
(c).	S-11F	Velocity pickup and accelerometers
(d).	S-11C	Velocity pickup and accelerometers
(3).	System Functions:	
(a).	S-11D-1	Controls the largest of displacement or acceleration; displacement only or acceleration only.
(b).	S-11D-2	Controls the largest of displacement or acceleration; displacement only or acceleration only.
(c).	S-11F	Controls the largest of G_x, G_y, G_z or one corresponding displacement.
(d).	S-11C	Controls displacement and acceleration at two different levels for two levels of operation.
(4).	Frequency Range:	5 to 5000 cps
(5).	Control Accuracy	±0.25 db for a 20 db change; ±0.5 db for a 40 db change. A 20 db change can be compressed to within 0.5 db; a 40 db change can be compressed to within 1.0 db.
(6).	Control Range	Greater than 45 db.
(7).	Signal Channel Gain	+15 db to –30 db, depending on control signal.
(8).	Reaction Time	0.04 second for 90% correction of a 40 db increase in control function; 0.25 second for decreasing control function. These times may be increased by a factor of 3.5 in the BELOW 10 CPS mode of operation.
(9).	Automatic Transfer	Automatic transfer between displacement and acceleration occurs at a preselected crossover frequency.
(10).	Metering	Continuous metering of displacement and acceleration.
(11).	Metering Accuracy	±5%
(12).	Input Level	1.0 volt rms
(13).	Waveform Distortion	Less than 0.5%
(14).	Transducer Calibration	System designed for nominal sensitivities of 21.0 mv rms per .001 per 100 cps, 68.1 mv rms per in/sec peak velocity or 10 mv rms per g peak acceleration (15 mv per g peak in S-11D-2 system).

SECTION 2
OPERATION

2-1. INSTALLATION

Initial installation of Ling Power Amplifiers and Vibration Testing Systems is normally accomplished by the customer, who is responsible for supplying the necessary space, materials and interconnections. When technical assistance is desired, arrangements may be made for Ling field service personnel to assist in checkout, test or briefing instructions.

2-2. OVER-ALL OPERATING PROCEDURES

a. Proper operation of the S-11 Servo System requires that a suitable signal source, power amplifier, shaker and instrumentation are all available and operating. The following are general considerations that must apply before the servo may operate correctly:

(1). The cycling oscillator or other signal source must cover the desired frequency range and signal level must be 1.0 volt rms (required by the S-10B Servo Control Amplifier).

(2). The power amplifier must have sufficient power to drive the shaker to the desired level which the servo is to control.

(3). The shaker must be capable of producing the level the servo is to control.

(4). The transducer(s) must be properly mounted and attached to the shaker, and correctly wired with shielded leads to avoid ground loops or excessive hum.

(5). The transducers used must have the correct calibrations, (see specifications, Section 1) or be provided with suitable accessory amplifiers or attenuators to properly match them to the servo. (Limited range adjustments on S-12 and 225)

(6). The remainder of the vibration testing system must be operating correctly without the servo, and the servo itself must be operating correctly.

b. In the paragraphs to follow, typical specifications will be assumed; the procedures outlined lead to setup of the most commonly used servo configurations that meet the assumed specifications. In carrying out these procedures for an actual specification, some modification to the steps listed may be necessary, and certain steps may be omitted; for example, if that portion of the system is already established at its correct level.

c. In carrying out the setup procedures, bear the following in mind at all times:

(1). The action of the servo is to hold constant the voltage output of the particular unit (S-12 or 225) which is controlling the servo at that time. This output voltage is related to the vibration quantities selected by the range switches on the unit in use. Consider that the servo operates to keep the reading constant on the meter scale, and that the vibration quantity to which that reading applies depends on what the meter is set to measure. Once properly set up, the servo will continue to regulate other levels of vibration controlled by

the range switches on the 225/SP-225 or by the range switch for each channel of the S-12D. Changing the acceleration level from 20 g to 6.33 g is accomplished, for example, by rotating the VECTOR G switch on the 225 monitor from the 30 g position to the 10 g position.

(2). The level controls on the S-12 and on the SP-225 switch panel act like verniers to permit attainment of vibration levels that are in between the 10 db and 20 db steps of the multiplier switches.

(3). For proper operation of any configuration of the servo, the GAIN REDUCTION meter on the S-10B Servo Control Amplifier must be indicating in the operating range; somewhere between 10 db and –40 db, and preferably in the vicinity of –15 db. This meter indicates the plate current of the gain controlled stage in the S-10B; the higher the current, the higher the gain in that stage. The meter therefore has a reverse scale which indicates gain reduction, approximately, in db.

(4). The master gain control, a part of the vibration testing system external to the S-11 Servo System, is normally located after the S-10B; that is, inside the servo loop. The setting of the master gain control will determine whether the servo is in its operating range. (Operation could be with the master gain control ahead of the S-10B and hence outside the loop, but this could lead to the possibility of excessive signal at the input to the S-10B and cause possible distortion or overload) For example, if the master gain control is turned down too far, the servo control amplifier even at maximum gain may produce insufficient signal to drive the shaker to the level of vibration the servo is expected to control; as the gain control is advanced, gain gradually compresses in the control amplifier so that a desirable operating point may be established.

(5). In all of the test examples to follow, the procedure is generally one of establishing the proper settings on the S-12 or 225/SP-225; the procedure insures that only the desired unit is switched into the circuit. Proper settings include those for the transducer, function and range switches, and output level controls.

2-3. S-11D-1 SERVO

a. The S-11D-1 Servo provides automatic changeover between displacement and acceleration, as frequency is varied. The usual application is the control of displacement below a crossover frequency and a automatic change to control of acceleration above that frequency. The S-11D-1 Servo has one S-12 D and G Amplifier, one DA-10B Control Selector, and one S-10B Servo Control Amplifier. The DA-10B switches automatically to the output having the largest signal level.

b. Assume the following specification and conditions:

(1). 10 to 40 cps, constant displacement of 0.25" da.

(2). Above 40 cps, constant acceleration of 20 g peak.

(3). Automatic crossover at 40 cps.

(4). Transducer; velocity pickup to J1 on S-12.

c. The objective of the setup procedure is to cause automatic changeover from displacement to acceleration control at 40 cps, and proper regulation for each channel. The displacement channel is set up first; then the acceleration channel. Proceed as follows:

(1). Set the oscillator or signal source to less than 40 cps, and adjust for 1.0 volt rms input to the S-10B Servo Control Amplifier.

(2). Set the S-12 controls:

CONTROL	POSITION
VELOCITY PICKUP switch (S2)	No. 1
Accelerometer Selector (S3)	DIFFERENTIAL VELOCITY
Function Switch (S1)	"D"
Acceleration range switch (S4)	50 g
Displacement range switch (S5)	X 1.0
DISPLACEMENT INCHES TOTAL (R39)	to less than 0.25 (to protect specimen)
ACCELERATION "G" VECTOR (R22)	to less than 20 (to protect specimen)

(3). Turn on the power amplifier and increase the amplifier master gain control until the GAIN REDUCTION meter on the S-10B Servo Control Amplifier indicates –15 db. The servo should now be controlling the displacement level indicated on the S-12 "D" meter.

(4). Adjust the DISPLACEMENT INCHES TOTAL control until the "D" meter indicates 0.25 inch da; recheck the GAIN REDUCTION meter on the S-10B; readjust the amplifier master gain control, if necessary, to obtain a gain reduction of –15 db.

(5). Check the servo control by decreasing the frequency slowly to 10 cps; observe that displacement remains constant and the GAIN REDUCTION meter reading remains in its operation range. As the lower frequencies are reached, the BELOW 10 CPS position may be selected on the S-10B function switch. (Use BELOW 10 CPS unless faster response is required.)

(6). With the power amplifier off or the amplifier turned down, reset the oscillator to some frequency greater than 40 cps, and note the reading of the "G" meter. Turn the S-12 function switch (S1) to "G"; adjust the ACCELERATION "G" VECTOR control (R22) until the meter reading is 20 g. The servo should now be controlling on acceleration.

(7). Increase the frequency gradually to the upper limit called for by the specification; observe the GAIN REDUCTION meter to be sure it remains constant at 20 g. If shaker resonances that drive the servo out of range are encountered, the amplifier master gain control may need resetting to shift the operating point. In an extreme case where the shaker resonance is in excess of the 40 db dynamic range of the servo, filter equalization or a manual control of gain may be necessary.

(8). Turn the S-12 mode switch (S1) to AUTOMATIC and decrease the frequency slowly to 40 cps. Observe the indicator lamps on the DA-10B, and the S-12 "D" and "G" meters. Automatic changeover from acceleration to displacement should take place as frequency is lowered past 40 cps.

2-4. S-11D-2 SERVO

a. The difference between the S-11D-2 Servo and the S-11D-1 Servo is that the Model 225 Signal Monitor is used in place of the S-12; the mode switch and level controls of the S-12 are incorporated into the SP-225 Switch Panel. The 225 Signal Monitor also supplies outputs related to both acceleration and displacement; they are obtained from an accelerometer input instead of a velocity transducer input. The Model 225 Signal Monitor INCHES D.A. and VECTOR "G" switches control the range in 10 db steps.

b. Assume the following specifications and conditions:

(1). 10 to 40 cps, constant displacement of 0.25" da.

(2). Above 40 cps, constant acceleration of 20 g peak.

(3). Automatic crossover at 40 cps.

(4). Transducer: accelerometer via preamplifier to J 101 input on 225 Signal Monitor.

c. The purpose of the setup procedure is to cause automatic crossover between displacement and acceleration control (at 40 cps) and to establish proper regulation for each channel. The displacement channel is set up first; then the acceleration channel. Proceed as follows:

(1). Set the oscillator or signal source to less than 40 cps, and adjust the output level for 1.0 volt rms at the input of the S-10B Servo Control Amplifier.

(2). Set the 225 Monitor controls:

CONTROL	POSITION
INCHES D.A. (S101)	0.5
VECTOR "G" (S301)	30 G
power switch	ON

(3). Set the SP-225 switch panel controls:

CONTROL	POSITION
D level (R1)	Full CCW
G level (R2)	Full CCW
Function selector (S1)	D

(4). Turn on the power amplifier and increase the amplifier master gain control until the S-10B GAIN REDUCTION meter indicates −15 db. The servo should now be controlling at the displacement level indicated on the 225 Signal Monitor displacement meter.

(5). Adjust the D level control on the SP-225 Switch Panel unit until the 225 Signal Monitor displacement meter indicates 0.125 inch peak (0.25 inch da, serial no. 86 and above).

(6). Readjust the amplifier master gain control as necessary to bring the S-10B GAIN REDUCTION meter to a −15 db indication.

(7). Check the servo control by decreasing frequency slowly to 10 cps, and observe that displacement remains constant and the GAIN REDUCTION meter reading remains in its operating range. As the lower frequencies are reached, the BELOW 10 CPS position may be selected on the S-10B function switch.

(8). With the power amplifier off or the amplifier master gain down, reset the oscillator to a frequency greater than 40 cps. Switch the SP-225 function selector (S1) to the G position; adjust the SP-225 G level control (R2) until the meter reading is 20 g. The servo should now be controlling on acceleration.

(9). Increase the frequency gradually to the upper limit called for by the specification and observe the GAIN REDUCTION meter to be sure it remains in the operating range. Check the acceleration meter to be sure that acceleration remains constant at 20 g. If shaker resonances are encountered that drive the servo out of range, the amplifier master gain control may need resetting to shift the operating point. In an extreme case where shaker resonance is in excess of the 40 db dynamic range of the servo, filter equalization or a manual control of gain may be necessary.

(10). Turn the function switch on the SP-225 Switch Panel to AUTOMATIC and decrease the frequency slowly to 40 cps. Observe the indicator lamps on the DA-10B and the 225 Signal Monitor meters. Automatic changeover from acceleration to displacement should take place as frequency is lowered past 40 cps.

2-5. S-11F SERVO

a. The S-11F Servo is designed for multiple level control, or for control on up to three axes. Three S-12 units are used, with three DA-10B selectors (see figure 3-1). In setting up this system, the same general procedure as specified for the S-11D-1 servo (paragraph 2-3) is followed for each S-12; in two cases the S-12 units indicate acceleration only. (It will be helpful to desensitize all S-12 units not actually being adjusted, to insure that the DA-10B selectors are switched to control on the quantity being established)

2-6. S-11C SERVO

a. The S-11C Servo is designed to control two levels of displacement and two levels of acceleration. The set up procedure for the S-11C is the same as the S-11D-1, except that the servo is set up to crossover at two different frequencies; the procedure follows:

(1). Turn the SW-10A to $d_1\ g_1$ and set up servo 1.

(2). Turn the SW-10A to $d_2\ g_2$ and set up servo 2.

(3). Turn the SW-10A to $d_1\ g_1\ d_2\ g_2$ for operation.

b. The following example shows the type of specification the S-11C will control:

(1). 10-40 cps, constant displacement of 0.25" da.

(2). 40 cps, automatic crossover to 20 g.

(3). 40-115 cps, constant acceleration of 20 g.

(4). 115 cps, automatic crossover to 0.03" da.

(5). 115-180 cps, constant displacement of 0.03" da.

(6). 180 cps, automatic crossover to 50 g.

(7). 180-2000 cps, constant acceleration of 50 g.

(8). Transducer :

(a). One velocity pickup to both S-12's (J1 or J2).

(b). One accelerometer, via a preamplifier, to each S-12 (J3, J4A or J4B).

c. Figure 2-1 is a log log plot of the example test specification listed above.

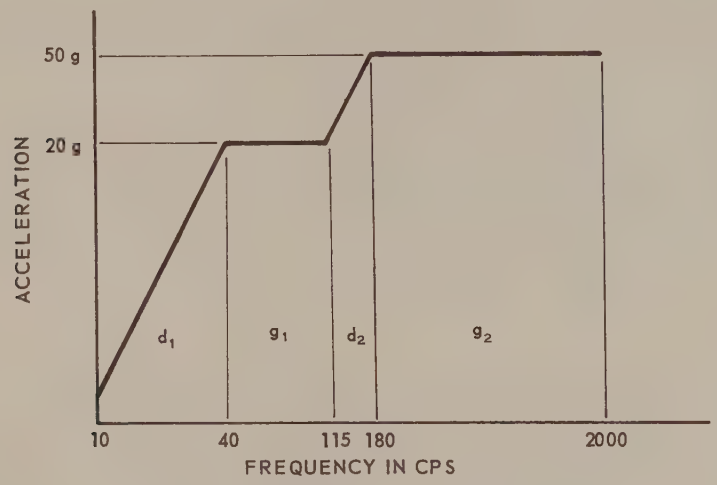


Fig. 2-1 Model S-11C, Servo Control Plot

2-7. RANDOM - PLUS - SINE - WAVE OPERATION

a. The S-11 servo system is designed for sine wave operation. Certain test specifications may require the simultaneous application of random signals (having some prescribed acceleration characteristic) and sine wave signals (cycling over some specified frequency range). In these tests, the equipment configuration is set up so the S-10B Servo Control Amplifier controls only the sine wave signal prior to mixing with the random signal. The random signal is set up first, following the procedure applicable to the particular equipment in use; it is generally set up by equalizing the shaker response and establishing the prescribed acceleration density characteristic; this is done with the servo out of the circuit, or operating at maximum control amplifier gain. When the random signal portion of the test is established, then the sine wave portion is set up, preferably (but not necessarily) with the random signal turned off. The servo is set up following the procedure given in this section, to control at the levels and frequencies specified.

b. When the random and sine wave specifications have been independently established, the sine wave output of the S-10B Servo Control Amplifier and the random signal may be mixed together in the Ling MA-2A Sine-Noise Mixer. The servo will continue to operate, even though its input signal from the vibration pickups on the shaker is now noisy. Tests have shown that good servo operation is maintained with signal-to-noise ratios as high as 2:1. Operation depends on the spectrum established for the noise; some interaction may be expected where the noise spectrum is narrow at sine wave frequencies within this narrow spectrum.

SECTION 3
PRINCIPLES OF OPERATION

3-1. INTRODUCTION

a. The Ling Model S-11 Servo System is designed to hold constant one of the three basic quantities of acceleration, velocity, or displacement measured at a shaker. Depending on the system configuration, one of these quantities can be held constant over a portion of the frequency spectrum; control will shift automatically to some other quantity, or to a new level of the same quantity over some other portion of the frequency spectrum. The S-11 is designed for sine wave vibration testing, and its use eliminates the necessity for filters, equalizers and other signal conditioners to compensate for shaker response; this is providing the shaker resonances are within the dynamic range of the servo. Sine wave testing is thus accomplished easier and faster than is possible without the use of the servo.

b. The S-11 Servo System may take on a number of configurations, depending on the particular application. Basic variable components of the system are the S-12 D & G Amplifier, the 225 Signal Monitor, the SP-225 Switch Panel, the S-10B Servo Control Amplifier and the DA-10B Control Selector. Each of these units contain their own power supply. One or more S-12 units and/or one or more 225/SP-225 units are used to supply the desired control signals from the transducers mounted on the shaker. One or more DA-10B Control Selectors are used to automatically select the signal controlling the servo control amplifier. In all cases, one S-10B Servo Control Amplifier is used.

c. This manual is applicable to all the configurations of the S-11 Servo, and will describe the most common used. The discussion here relates to the servo systems rather than to the details of each component chassis. Complete instruction manuals for each unit will be found following this manual.

3-2. S-11D-1 SERVO (See figure 3-1)

a. The S-11D-1 Servo System, is the simplest and most widely used. The block diagram (figure 3-1) shows the complete vibration testing system including cycling oscillator or other signal source (such as a tape recorder), signal conditioners (filters, graphic equalizers, peak notch filters, etc. where used), S-11 Servo components, power amplifier, shaker, and velocity pickups. The S-11D-1 servo can maintain either displacement or acceleration constant, when receiving input signals proportional to velocity. A more restricted version of this system is one using an accelerometer, which will only hold acceleration constant and not displacement.

b. The S-12 D & G Servo Amplifier is a unit that has both "D" and "G" meters and displacement and acceleration outputs suitable for control purposes. The S-12 must have a velocity transducer to produce a signal proportional to displacement, since only single integration is provided. The S-12 has provision for two accelerometer inputs; these are used to supply acceleration signals and metering only. There are two velocity inputs, and a switch that selects either of these two inputs; thus, one transducer may be mounted on the shaker table and another on the specimen, or at some angle to the first.

c. The DA-10B is an electronically controlled selector which automatically switches its output to the larger of its two inputs. In the S-11D-1 Servo, the two inputs are proportional to displacement and acceleration; the outputs of the S-12 are manually or automatically selected; in the AUTOMATIC position the DA-10B selects the larger of two signals and supplies this signal to the servo control amplifier.

d. The S-10B Servo Control Amplifier is common to all of the S-11 Servo Systems; it is the unit which actually controls the signal level in response to the control voltage applied to it.

e. The usual application of the S-11D-1 servo is to hold displacement constant at low frequencies, with automatic changeover to acceleration control at higher frequencies. The requirement for such operation is readily visualized by considering the limitations of shakers. Shakers are necessarily limited to some maximum double amplitude displacement, (usually 0.5 inches) which is primarily a low frequency limitation; they are also limited, by virtue of their force pound rating, to some maximum peak acceleration, which is primarily a high frequency limitation. The relationship between double amplitude displacement (D) and peak acceleration (g) is:

$$g = 0.051Df^2 \qquad (1)$$

where g is the peak (positive or negative) acceleration in g units, D is the double amplitude (peak-to-peak) displacement in inches and f is the frequency in cycles per second. Solving this relation for f gives:

$$f = 4.42\sqrt{\frac{g}{D}} \qquad (2)$$

which is known as the crossover frequency; above this frequency acceleration governs and below this frequency displacement governs. Thus if the shaker is limited to 0.5 inch da at low frequencies, and 50 g at higher frequencies, the crossover frequency given by Equation 2 is:

$$f = 4.42\ \frac{50^{1/2}}{0.5} = 44.2\ \text{cps} \qquad (3)$$

f. At this frequency, both conditions simultaneously exist. Above this frequency, displacement obtainable is limited by acceleration; below it, acceleration obtainable is limited by displacement.

g. The prime concern is not with establishing the maximum limits imposed by the shaker, but with the limitations imposed by the specimen or by the test specification. These limitations are frequently stated in terms of a constant displacement below some frequency, followed by a constant acceleration above that frequency. The S-11D-1 servo may be used to establish these conditions automatically, irrespective of variations in shaker response (within the 45 db dynamic range of the servo) over the frequency range.

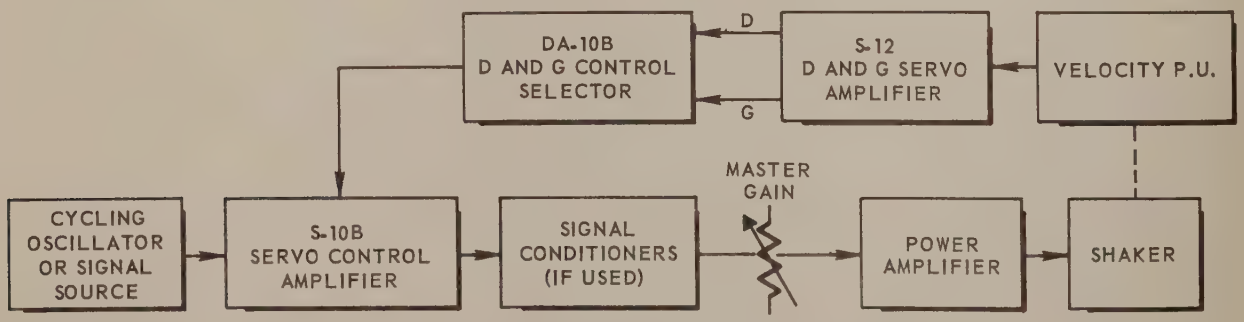


Fig. 3-1 Model S-11D-1 Servo D or G, Block Diagram

3-3. S-11D-2 SERVO (See figure 3-2)

a. This Servo is esentially the same as the S-11D-1 just described, except that a Model 225 Signal Monitor and associated SP-225 Switch Panel have been substituted for the S-12. The 225 Signal Monitor is essentially complementary to the S-12; that is, where the S-12 produces displacement and acceleration from a velocity transducer input and provides only acceleration from an accel-

erometer input, the 225 produces displacement and acceleration from an accelerometer input and provides only displacement from a velocity transducer input. The S-11D-2 servo applies where an accelerometer is to be used as a transducer at the shaker; the S-11D-1 servo applies where a velocity pickup is to be used.

b. The 225 Signal Monitor is calibrated for an input signal of 30 mv rms per g peak acceleration; it has an input impedance which is about 25 K ohms resistive (variable over a limited range). The accelerometers frequently used are the Endevco Model 2213 piezo-electric type, which require a capacitive input impedance as well as signal amplification for proper matching into the 225 Signal Monitor. The Endevco 2614 Input Amplifier is used between the 225 Signal Monitor and the accelerometer. Provision is made in the 225 Signal Monitor for supplying the filament and plate power required by this amplifier, from the 225 Signal Monitor power supply.

c. The 225 Signal Monitor requires the use of an external switch to select between operation on D only, G only, MANUAL, or AUTOMATIC. This is the function of the SP-225 switch panel, shown in Figure 3-3. The displacement and acceleration outputs from the 225 Signal Monitor are individually adjustable by potentiometers R1 and R2, selected by switch S1. In the MANUAL position, S1 grounds the AGC input to the S-10B so the vibration level is established manually by using the master gain control. In the D or G positions of switch S1, control is on displacement or acceleration only and is independent of the state of the DA-10B Control Selector.

d. The AUTOMATIC position of S1 switches the S-10B AGC input to the DA-10B output; control is automatically switched to the larger of the two signals (acceleration or displacement) applied to the DA-10B selector unit.

e. The S-11D-2 servo is used in the same manner and for the same purpose as the S-11D-1 servo.

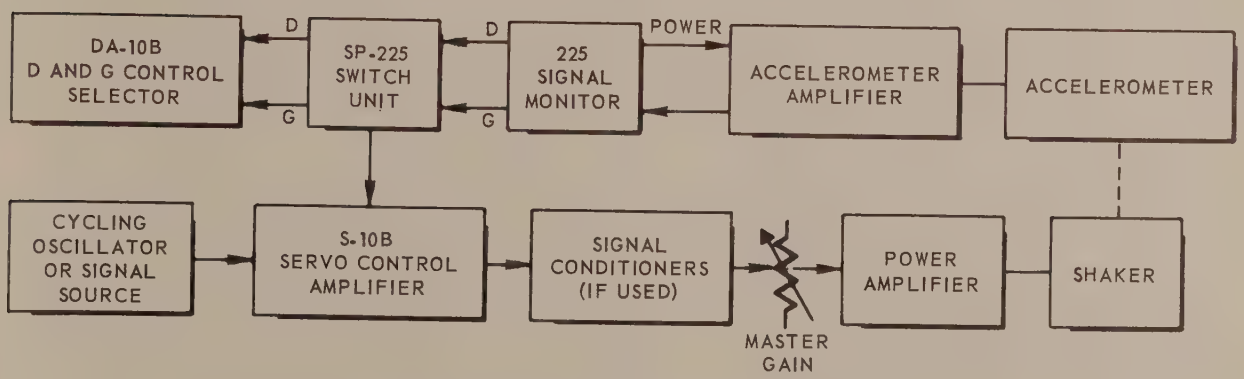


Fig. 3-2 Model S-11D-2 Servo D or G, Block Diagram

3-4. S-11F SERVO (See figure 3-4)

a. Figure 3-4 shows the S-11F servo, which is designed for work where servo control is established on more than one axis of vibration. Two accelerometers and a velocity pickup are used; the accelerometer inputs are applied to two S-12 units through a suitable cathode follower to isolate the accelerometer impedances. (With certain types of accelerometers, an additional amplifier may be necessary either ahead of or in place of the cathode follower) It will be recalled that the S-12 produces acceleration output (only) when coupled to an accelerometer; the displacement outputs of two of the S-12 units are therefore not used in the S-11F servo. The third S-12 has a velocity input which supplies both acceleration and displacement outputs, arbitrarily shown as along the Z axis in Figure 3-4.

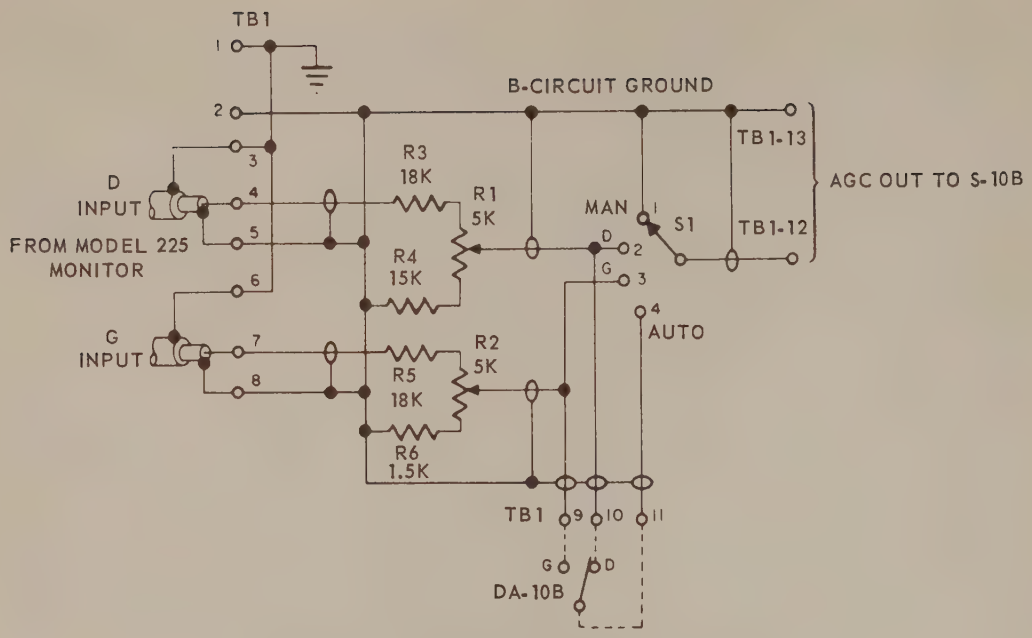


Fig. 3-3 Model SP-225 Switch Panel, Schematic

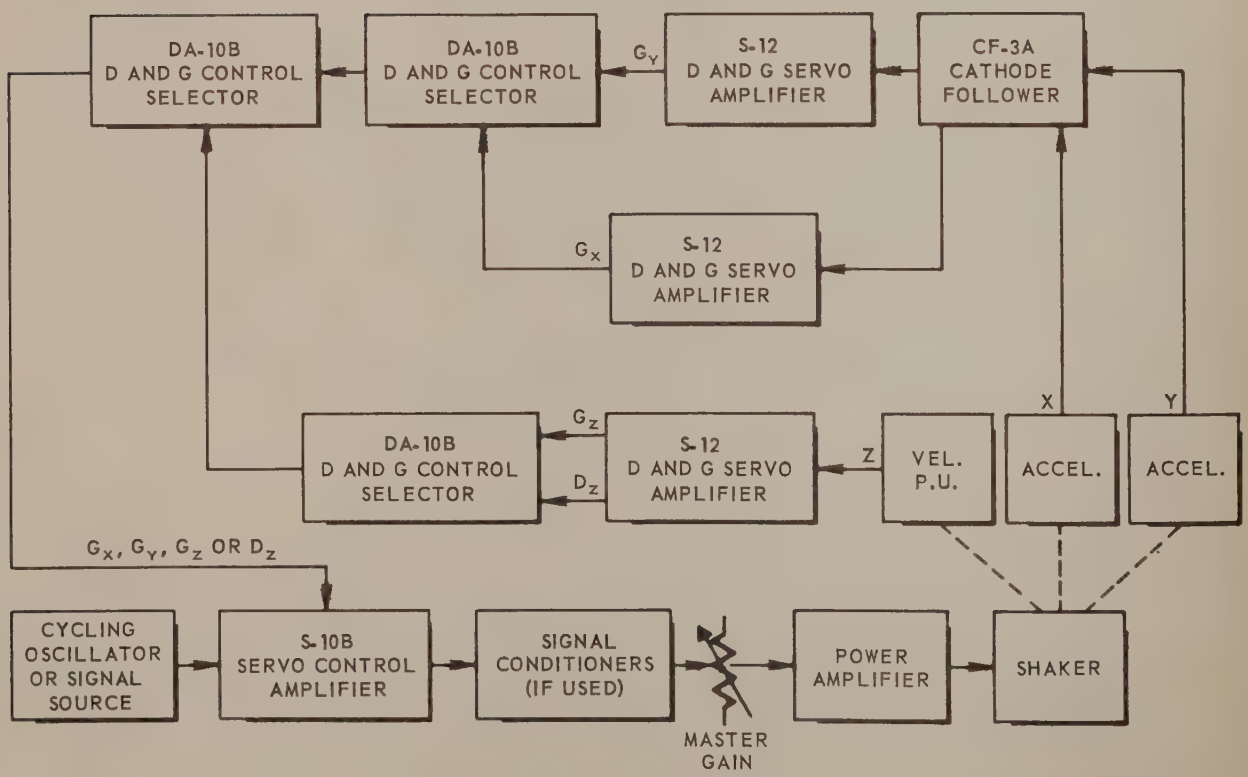


Fig. 3-4 Model S-11F Servo, Block Diagram

b. Three DA-10B units are used in the S-11F servo, arranged as shown in Figure 3-4; these select the largest of the four quantities as the control signal for the S-10B Servo Control Amplifier. This servo makes it possible to have control of acceleration along three different axes or at three different points on a specimen, and still achieve control based on displacement at the frequencies below crossover.

3-5. S-11C SERVO (See figure 3-5)

a. The S-11C four level Servo controls two different levels of acceleration and displacement. The S-11C can be operated with one velocity pickup and up to two accelerometers; a cathode follower is required between the accelerometer(s) and the S-12's.

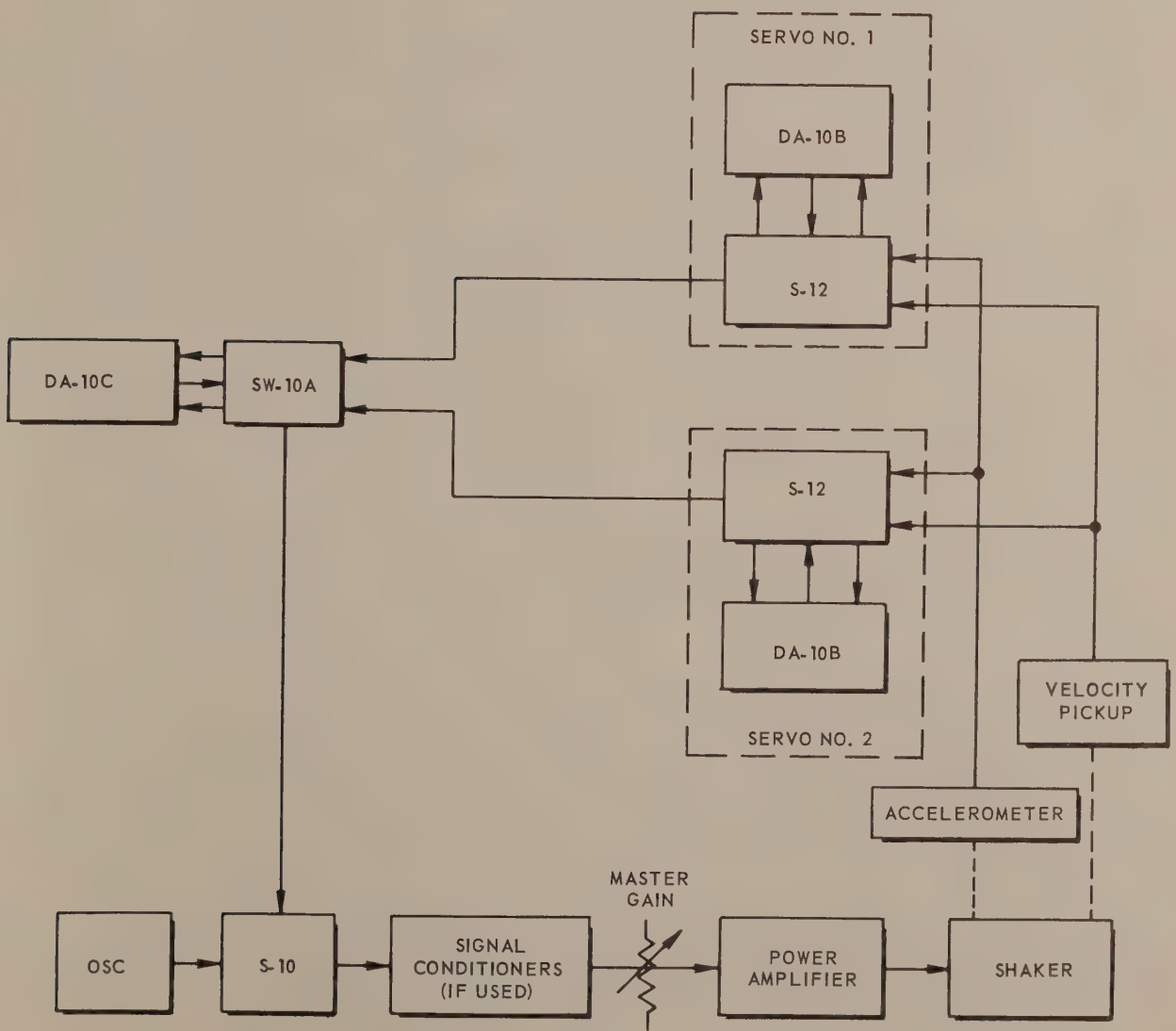


Fig. 3-5 Model S-11C Four Level Servo System, Block Diagram

b. The arrangement of the chassis in figure 3-5 are similar to two S-11D-1 servos; the difference is, the outputs of both S-12's are applied to the SW-10A which permits use of two S-11D-1 servos individually or combined into a S-11C. The d_1g_1 position (S-11D-1 No. 1) of the SW-10A disconnects the DA-10C, S-12 No. 2 and DA-10B No. 2 from the servo loop; the set up and operation of servo No. 1 is accomplished in this position. The set up and operation for servo No. 2 is accomplished in the d_2g_2 position. To operate the S-11C, the SW-10A is switched to $d_1g_1d_2g_2$; in this position, all components of the S-11C are connected. The servo is now ready for operation following the example outlined in paragraph 2-6.

NOTE

THE FRONT PANEL CONTROLS ON THE S-12'S ADJUST THE LEVEL OF EACH OF THE FOUR VIBRATION QUANTITIES (TWO OF DISPLACEMENT AND TWO OF ACCELERATION): THESE LEVELS ARE SET UP ACCORDING TO THE EXAMPLE SPECIFICATION OUTLINED IN PARAGRAPH 2-6. FIGURE 3-6 IS THEN A PLOT OF AGC LEVELS VERSUS FREQUENCY.

(1). S-11C operation starts at a frequency of 10 cps according to the example test specification. As frequency is increased, the output of S-12 No. 1 is applied to DA-10B No. 1 (refer to figure 3-6); DA-10B No. 1 selects the larger signal (d_1). The larger signal selected by DA-10B No. 2 is d_2; both signals are applied, through the SW-10A, to the DA-10C. The DA-10C selects the smaller of the two signals for application to the S-10B; in this case, the selected signal is d_1. The d_1 signal controls the gain of the S-10B.

(2). When the frequency reaches 40 cps, a condition is reached where d_1 and g_1 are equal; as frequency increases, acceleration increases and DA-10B No. 1 selects g_1 from S-12 No. 1. DA-10B No. 2 selects the larger signal from S-12 No. 2 which is d_2. Both signals are applied to the DA-10C through the SW-10A. Since the g_1 signal amplitude is less than d_2, the DA-10C selects the smaller signal g_2.

(3). When the frequency reaches 115 cps, g_1 and d_2 are equal. As frequency increases, the largest quantity appearing in S-12 No. 1 is g_1; the largest quantity appearing in S-12 No. 2 is d_2. The smaller of these two signals is selected by the DA-10C to be applied to the S-10B; this signal is d_2.

(4). When the frequency reaches 180 cps, d_2 and g_2 are equal. As frequency increases, DA-10B No. 1 selects the larger signal from S-12 No. 1 (g_1) and DA-10B No. 2 selects the larger signal from S-12 No. 2 (g_2). The DA-10C selects the smaller of the two signals which is g_2; this signal is applied to the S-10B.

3-6. OTHER CONFIGURATIONS

a. Other configurations of the S-11 are possible. For example, Model 225 Signal Monitors could be used in place of the S-12 units in the S-11F servo and an accelerometer substituted for the velocity pickup. Three SP-225 switch panels would be used. A configuration such as this would permit controlling the largest of any desired combination of three displacements or three accelerations.

b. It is apparent that many other configurations, even some involving tandem operation of more than one S-10B (to achieve continuous, rather than selected and switched, control by more than one vibration quantity) is possible using the basic building blocks of the S-11 system. These configurations are sometimes, although rarely used; the types shown are most common.

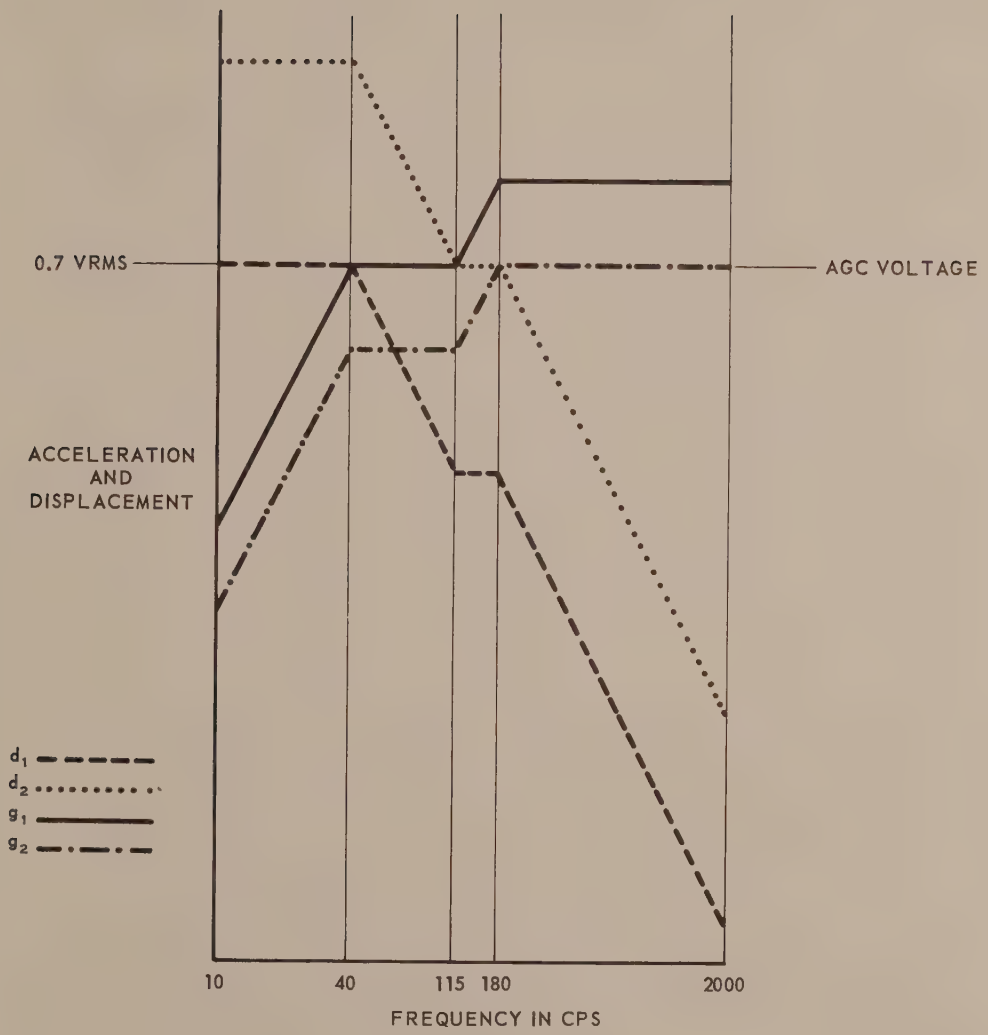


Fig. 3-6 Plot of AGC Output of S-12 Monitors

SECTION 4
MAINTENANCE

4-1. ANALYSIS

a. This section deals only with the S-11 servo taken as a system, and not with the individual units that make up that system. For maintenance instructions applicable to the component units (S-10B, S-12, DA-10B and 225) refer to the individual instruction manual.

b. Before attempting maintenance or repair of the S-11 Servo System, make certain that the system is actually at fault. The S-11 is only one portion of the complete vibration testing system comprised of signal source, signal conditioners, power amplifier, shaker, and instrumentation. Trouble may occur elsewhere, so a series of logical and orderly tests should be made to prove that the S-11 or some of its component units are actually at fault.

c. The first indication of trouble with the S-11 servo may be a failure to properly regulate the vibration quantity which is supposed to be held constant. If the displacement is to be held constant (since acceleration and displacement are related by the square of frequency) it is obvious that acceleration must increase as the square of frequency. It is perfectly normal for acceleration, and similarly velocity, to vary with frequency if displacement is being held constant; and indication to this effect should not be construed as a failure of the servo. If displacement varies when it is supposed to remain constant, this is an indication of improper operation (this applies to acceleration or velocity). When this indication is present, it may be due to improper setup of the S-11. For example, the S-10B may have been set up with the GAIN REDUCTION meter indicating too near one extreme or the other; in this case the servo cannot remain in its operating range when compensating for shaker resonances, or simply for the normal changes due to changing frequency. Observe the GAIN REDUCTION meter on the S-10B panel to see that it remains in the recommended operating range.

d. If difficulties are suspected in one S-12 or one 225 monitor of a multiple level system, a good (but not necessarily infallible) check is to compare one meter reading with another. In making such comparisons the meters must be set to read the same quantity at the same range; this will be the quantity being held constant by the servo, which controls whatever the meter is set to read. In making such tests, the accuracies and types of pickups supplying the different meters must be kept in mind; a 30 g accelerometer used at a 0.1 g level cannot be expected to remain as accurate as it would when used at a 25 g level.

4-2. TROUBLESHOOTING

a. The following are suggested causes and/or remedies for troubles that might appear in the S-11 Servo System when the system is operating with signal source, signal conditioner(s), power amplifier, shaker and pickup(s).

TROUBLE	REMEDY AND/OR CAUSE
Servo does not regulate.	Servo out of range; check S-10B GAIN REDUCTION meter.
	S-10B defective.
	Substitute a different S-12 and check operation.
	Accelerometer and/or velocity pickup bad.

TROUBLE	REMEDY AND/OR CAUSE
Servo regulates on some vibration quantities but not on others, levels comparable.	Defective S-12, 225, or VM-1A. Substitute meters, if possible, and recheck.
	Possible defective pickups (on multiple level servos).
Excessive distortion of Signal.	Defective S-10. Too short a time constant (low frequency distortion).
	Switch to BELOW 10 CPS on S-10B.
	Too high an input level from oscillator.
Hunting.	Usual characteristics or non-linearity within servo loop including power amplifier and shaker.
	Possible feedback of armature signal to input of S-10B due to ground loops or wiring changes; input of power amplifier may cause high frequency oscillations which the servo is unable to control.
	Check for hunting at various levels of vibration.
	Equalize phase or amplitude response, or both.
No automatic changeover.	Defective DA-10 unit.
	Improper adjustment of DA-10.
	Defective S-12 or 225 units.
Indicators do not operate properly.	Check lamp bulbs.
	Check relay operation in DA-10.
	Check to see that changeover is actually taking place; DA-10 may be defective.
Excessive hum modulation of vibration signal.	Check for ground loops or open shield on vibration pickup wiring, especially at shaker.
Inaccurate vibration readings on S-12, 225 or VM-1A.	Ensure that pickup calibration is correct for the metering unit, and vice versa.
	Defective S-12, 225 or VM-1A.
	Check mounting of pickups for alignment, looseness or rattle.
	Check orientation of accelerometers.

TROUBLE	REMEDY AND/OR CAUSE
Insufficient vibration obtainable.	Check S-10B for full output. Check power amplifier input power. Check for mismatch of shaker to power amplifier. Check for defective shaker or field supply. Check instrumentation, especially pickups. If pickups are mounted on fixture or specimen rather than on table, trouble may be due to resonance. Lower frequency and recheck. Check for proper input level to S-10B.

4-3. OSCILLATION PROBLEMS

a. Any servo system is subject to oscillation problems under certain conditions of amplitude and phase; the net over-all open loop gain characteristics include the power amplifier, shaker, vibration pickups and the S-11. The S-11 has been designed with an ample margin for stability when used with the usual amplifiers and shakers; oscillation or hunting difficulties might be experienced in certain installations, where the power amplifier and shaker are not well matched (power rating) or where pickups are mounted on fixtures or specimens having unusual resonance characteristics, especially non-linearities.

b. Each oscillation or hunting problem has its own peculiarities, and not too much can be said that will apply to all situations. Difficulties of this sort may occur at any frequency and the problem is frequently solvable by placing a band pass filter inside the servo feedback loop (between the S-10B output and the power amplifier). This action prevents vibration testing outside the filter cutoff frequencies, but may be acceptable where testing is within the filter bandpass frequencies. In other cases, some type of all pass phase correcting network, such as a lattice filter, may be useful in stabilization of the loop. If the oscillation problem is the result of non-linearities, a change in the operating point may correct it.

4-4. ADJUSTMENT

a. The adjustment procedure, including that for calibration, is specified in the instruction manual for each component chassis of the S-11 Servo System. Adjustments that apply to the system are described in Section 2 of this manual (Operation).

4-5. OTHER DIFFICULTY

a. In the event of troubles or problems not covered by this manual or by standard troubleshooting techniques, contact the factory, giving the serial numbers of servo components, Ling Number, conditions of use, and full description of problem. Ling field service personnel are constantly available for consultation on special problems concerning utilization or application of Ling equipment, and upon making the necessary arrangements, can be on the scene within 24 hours.

S-11-D1 Servo Schematic 30393H

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